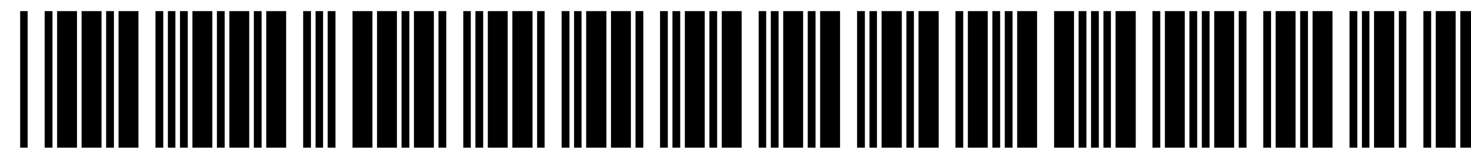
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Ohno et al.

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(45) **Date of Patent: *Sep. 21, 2021**

(54) **ENDOSCOPIC DEVICE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/701,154**

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(30) **Foreign Application Priority Data**

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A61B 1/05 (2006.01)
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(52) **U.S. Cl.**
CPC ***A61B 1/051*** (2013.01); ***A61B 1/00124*** (2013.01); *A61B 1/00126* (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC A61B 1/00124; A61B 1/042; A61B 1/051; H01L 2224/16225; H01L 2224/32225;
(Continued)

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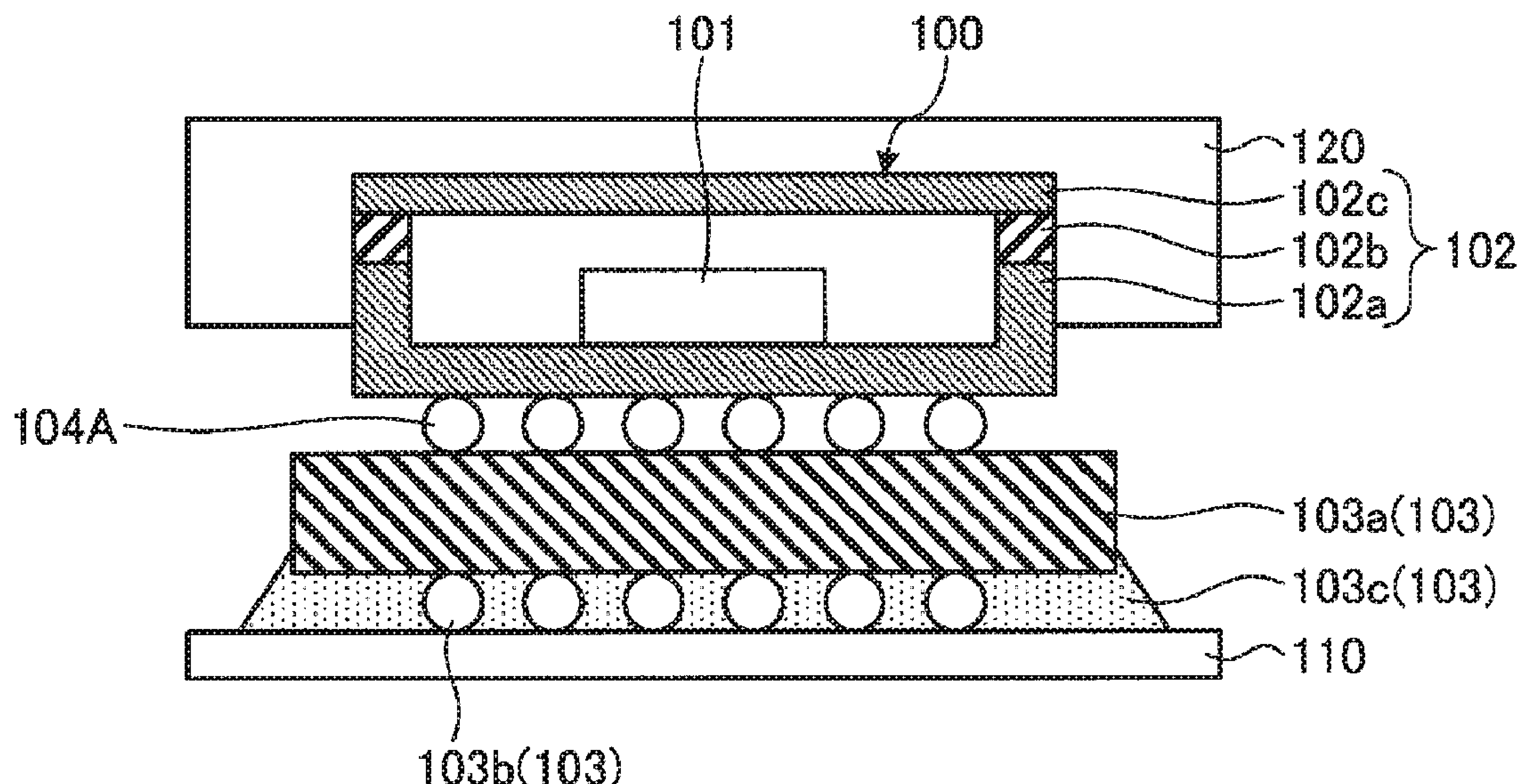
(74) *Attorney, Agent, or Firm* — Xsensus LLP

(57) **ABSTRACT**

There is provided an endoscopic device, including: an image sensor section including an image sensor that senses and converts lights into an electrical signal; a substrate that is electrically connected to the image sensor section; and an intermediate unit, interposed between the image sensor section and the substrate, that electrically connects the image sensor section and the substrate.

20 Claims, 8 Drawing Sheets



(51) **Int. Cl.**
H04N 5/225 (2006.01)
A61B 1/04 (2006.01)

(52) **U.S. Cl.**
CPC *A61B 1/042* (2013.01); *A61B 1/05* (2013.01); *A61B 1/053* (2013.01); *H04N 5/2253* (2013.01); *H05K 2201/10378* (2013.01)

(58) **Field of Classification Search**
CPC ... H01L 2924/00; H01L 33/48; H01L 33/483; H01L 33/56; H01L 21/563
See application file for complete search history.

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FIG. 1

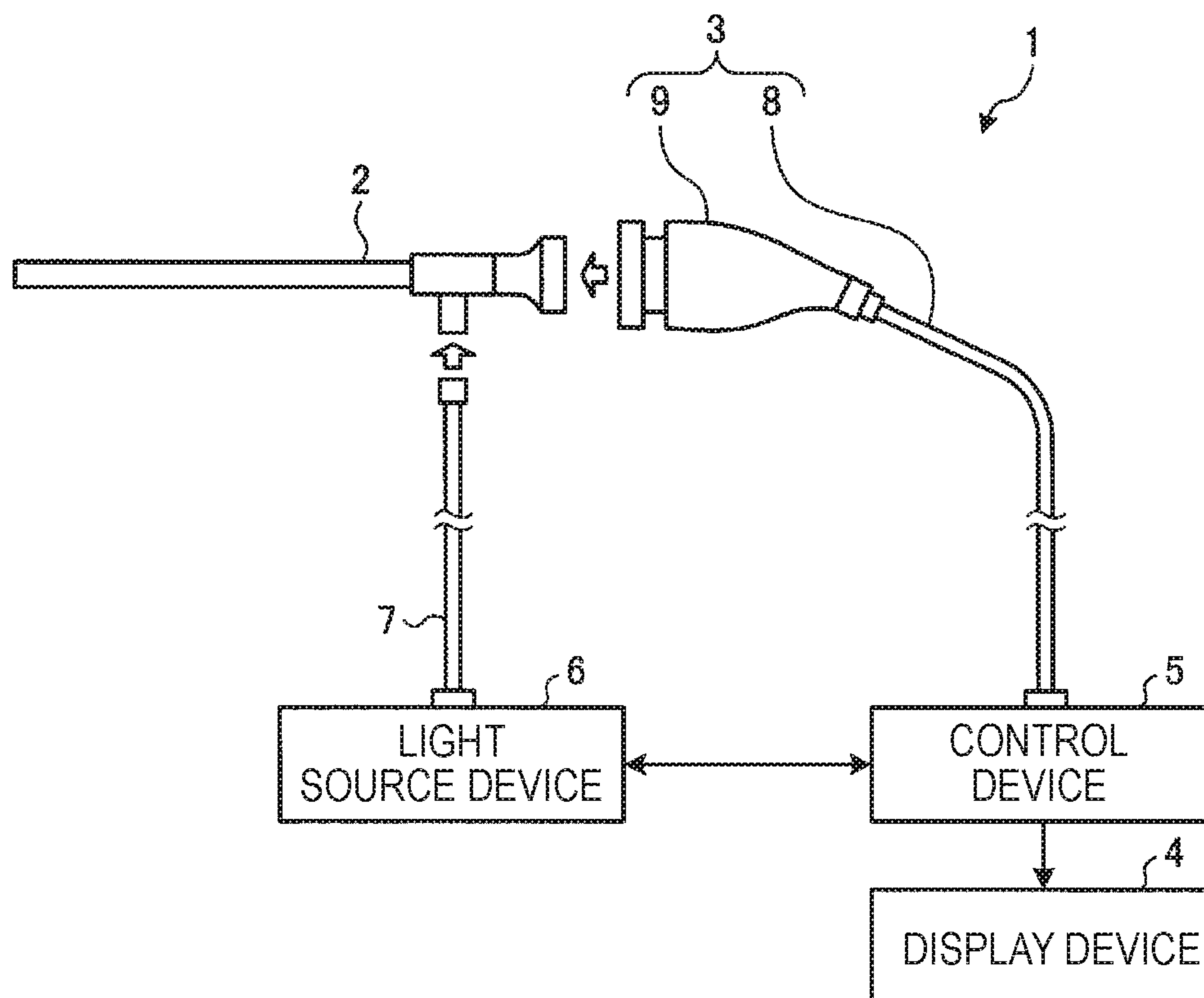


FIG. 2

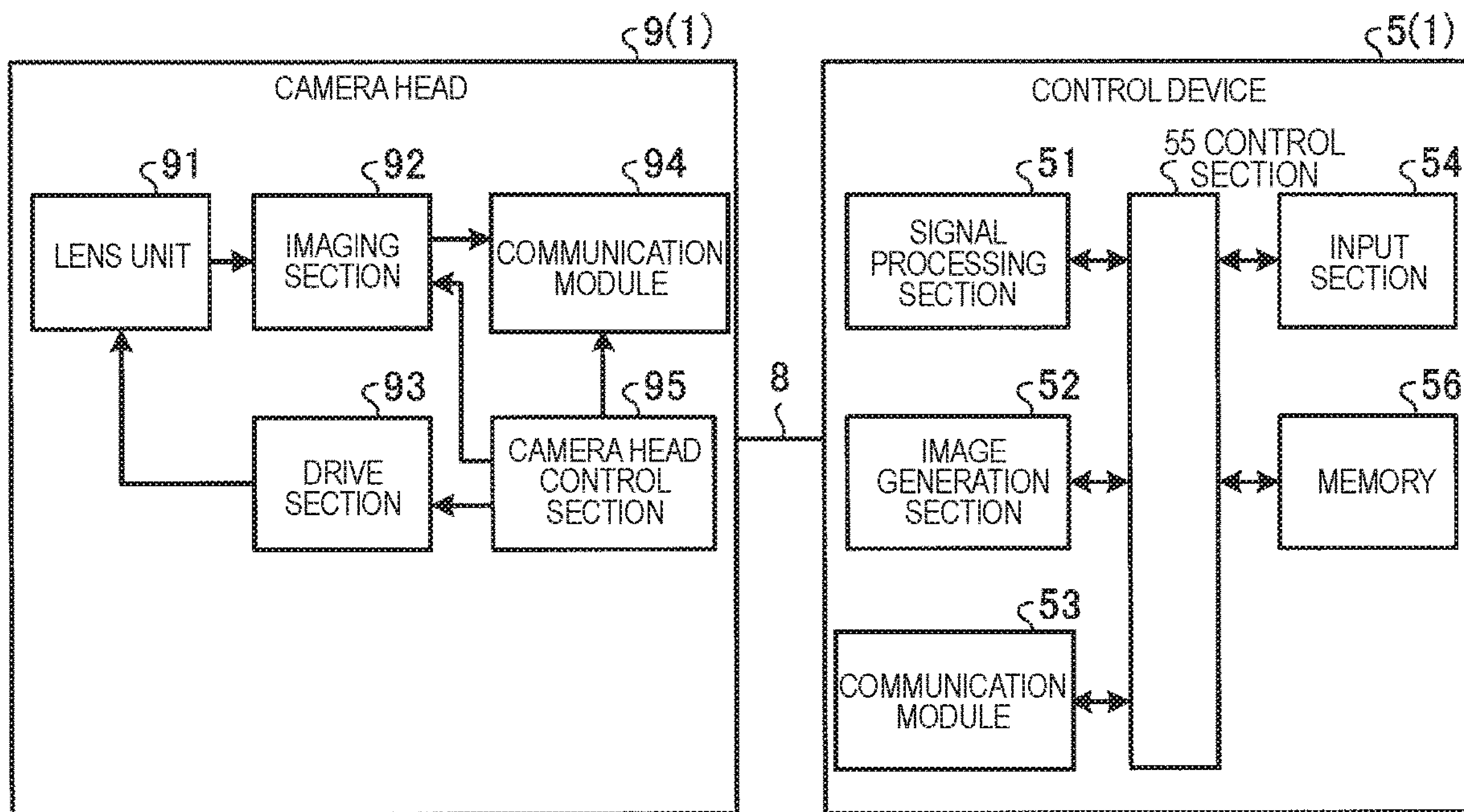


FIG. 3

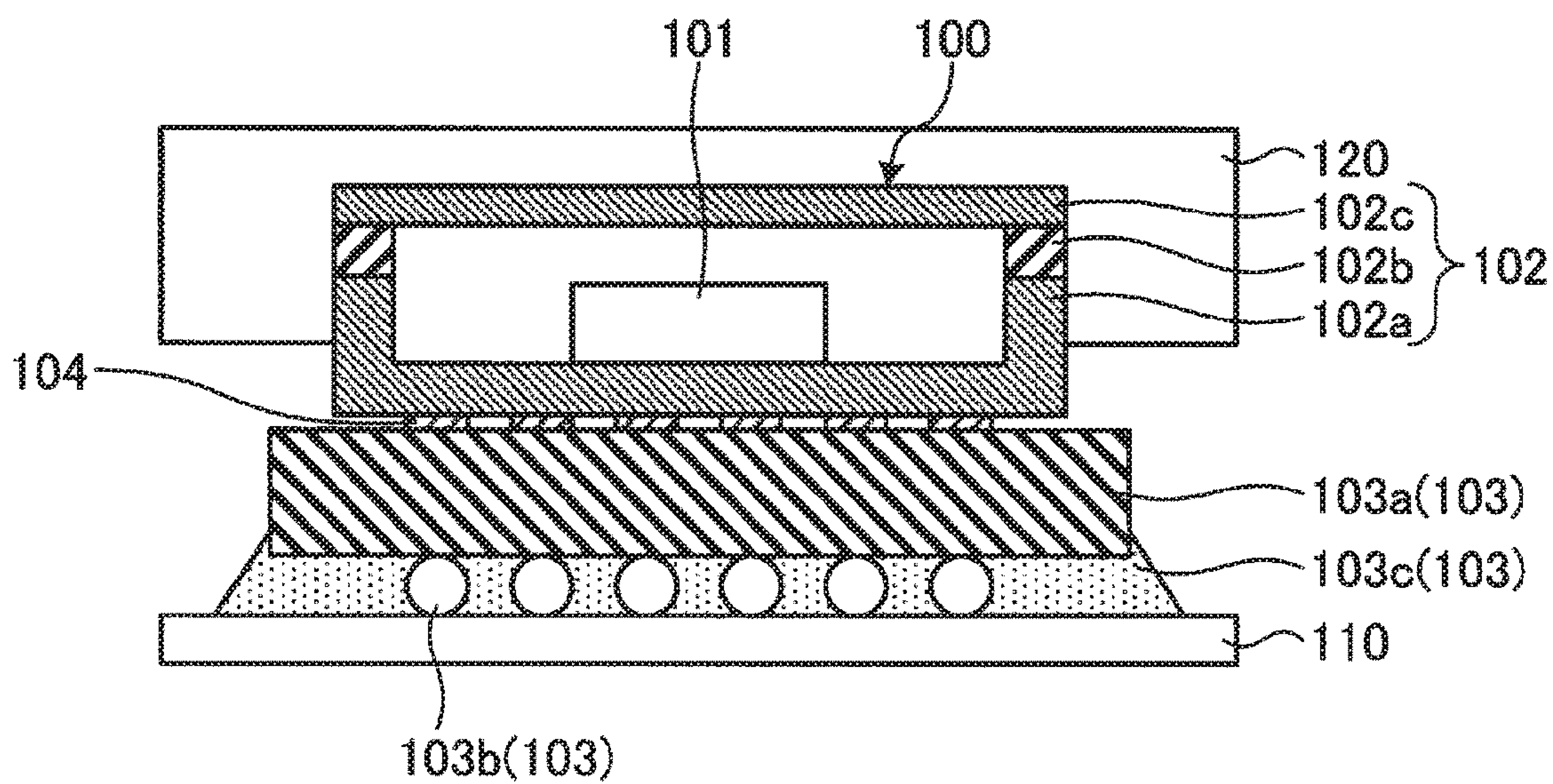


FIG. 4

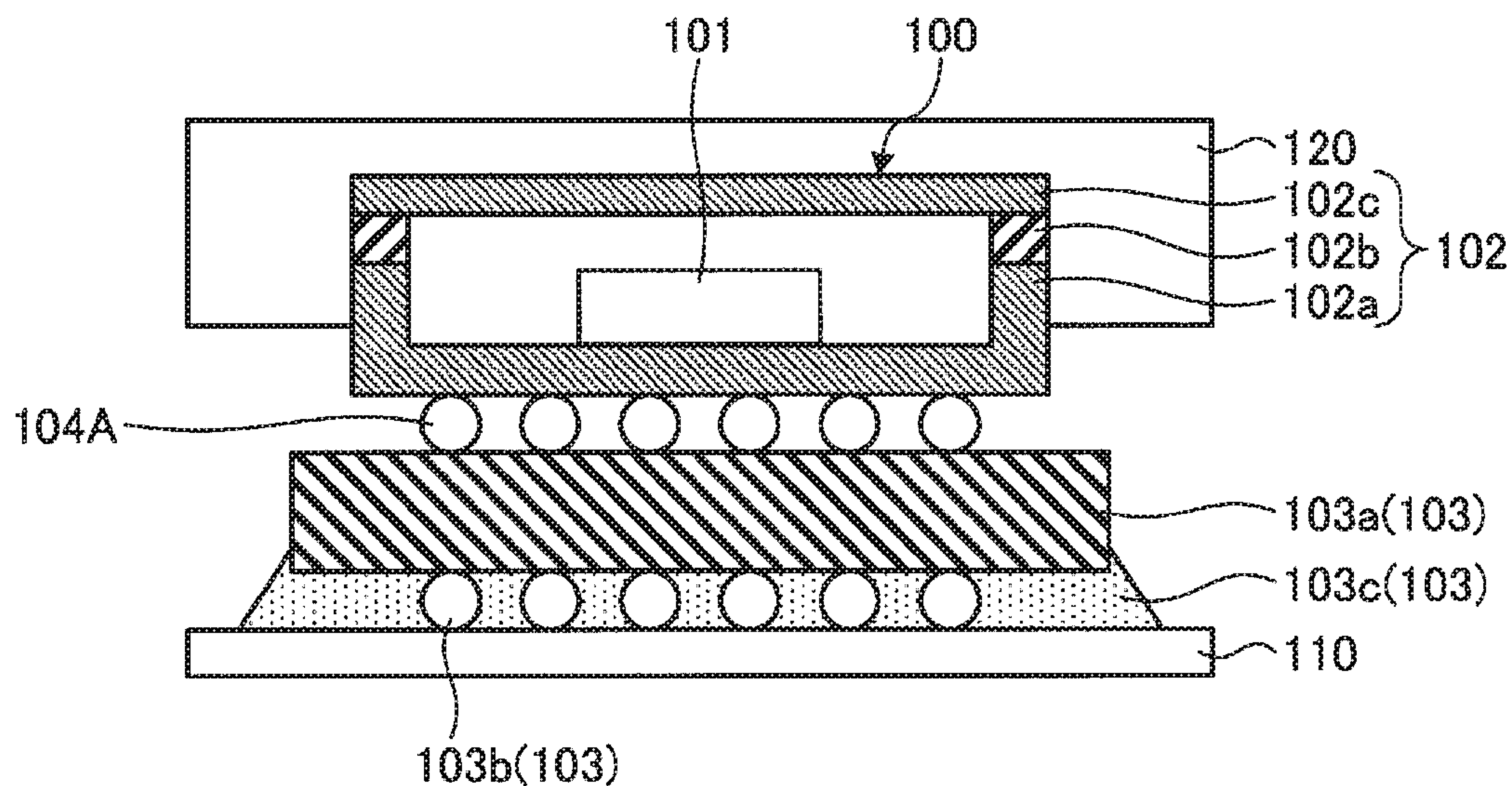


FIG. 5

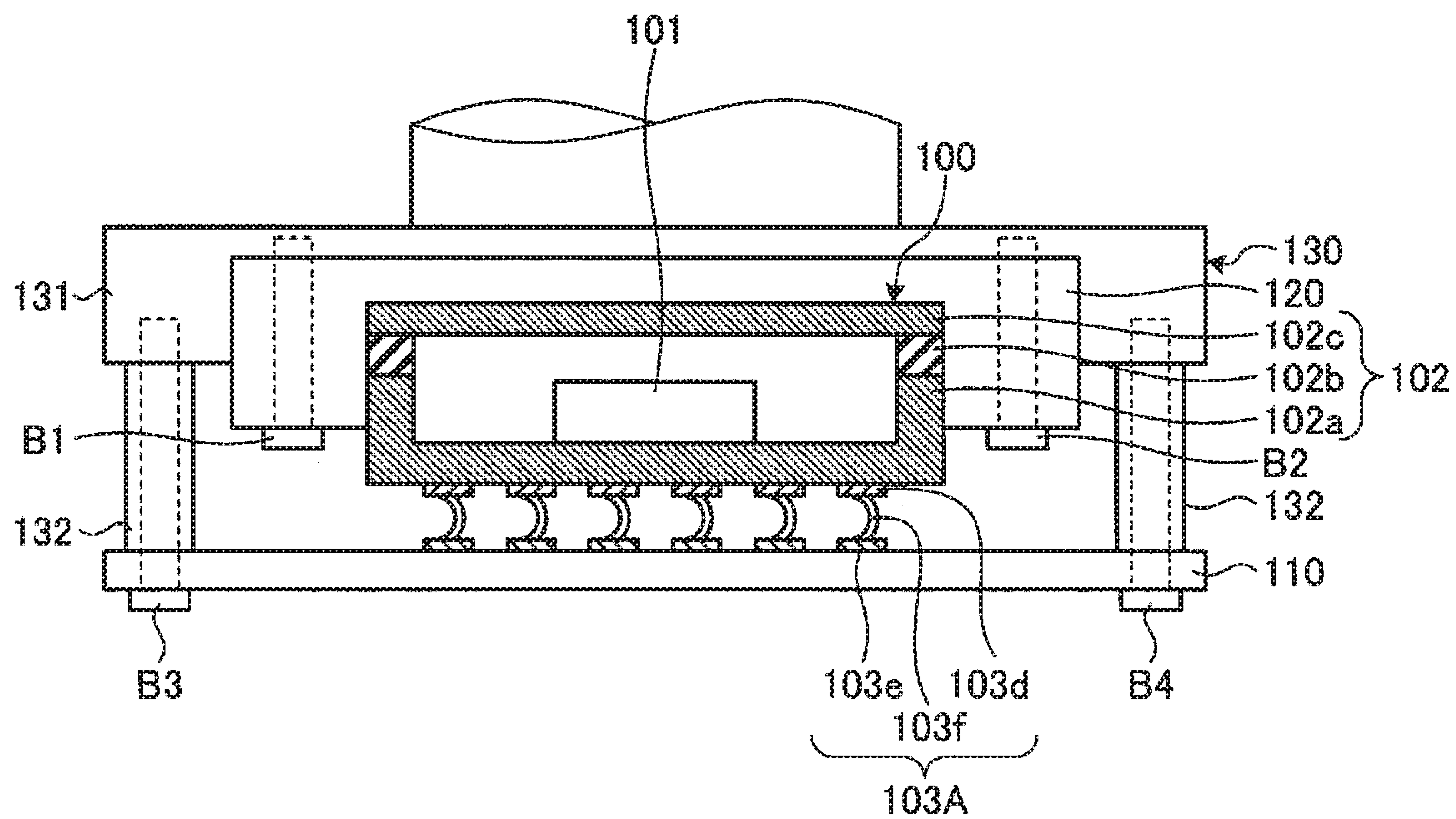


FIG. 6

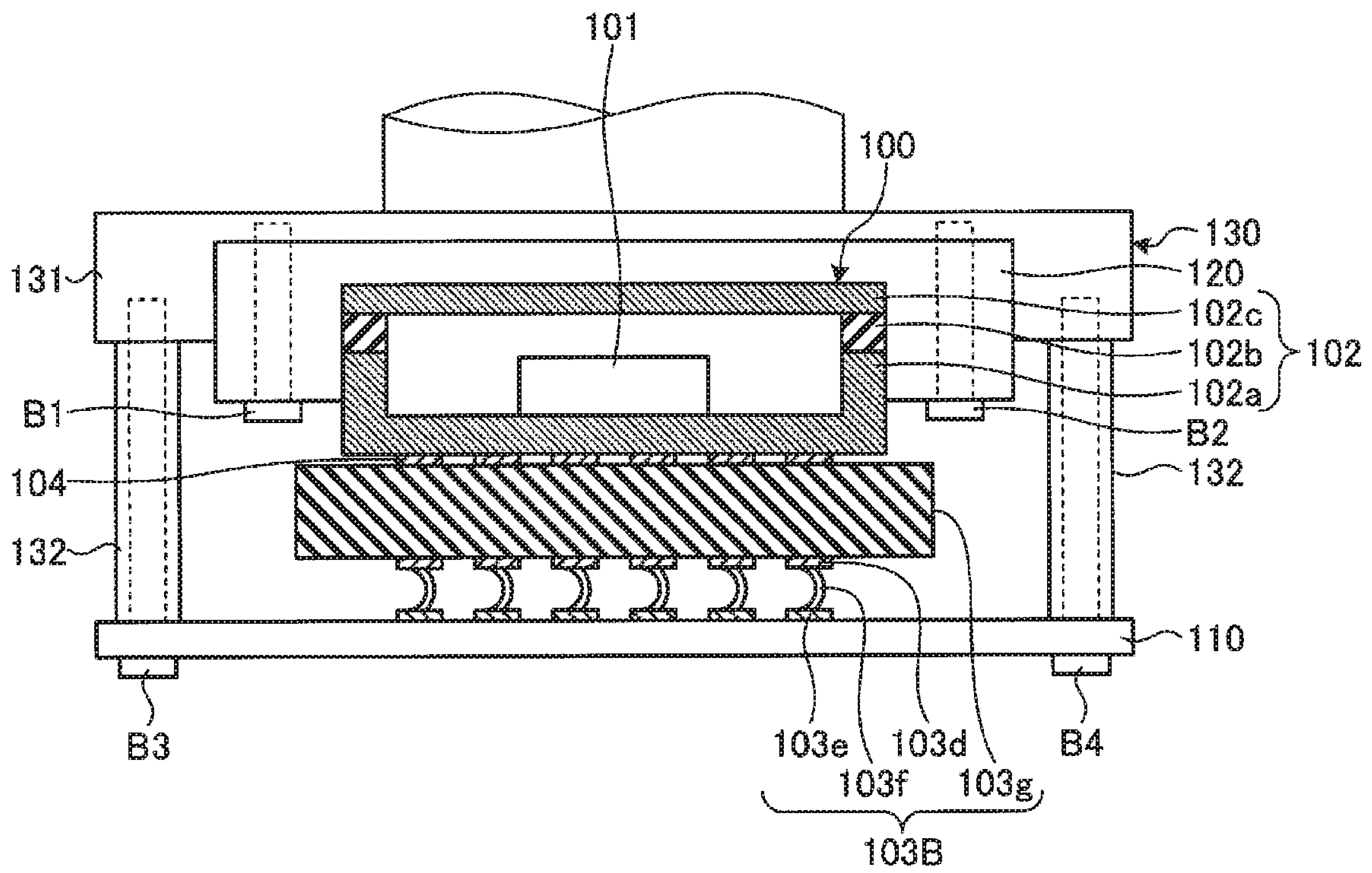


FIG. 7

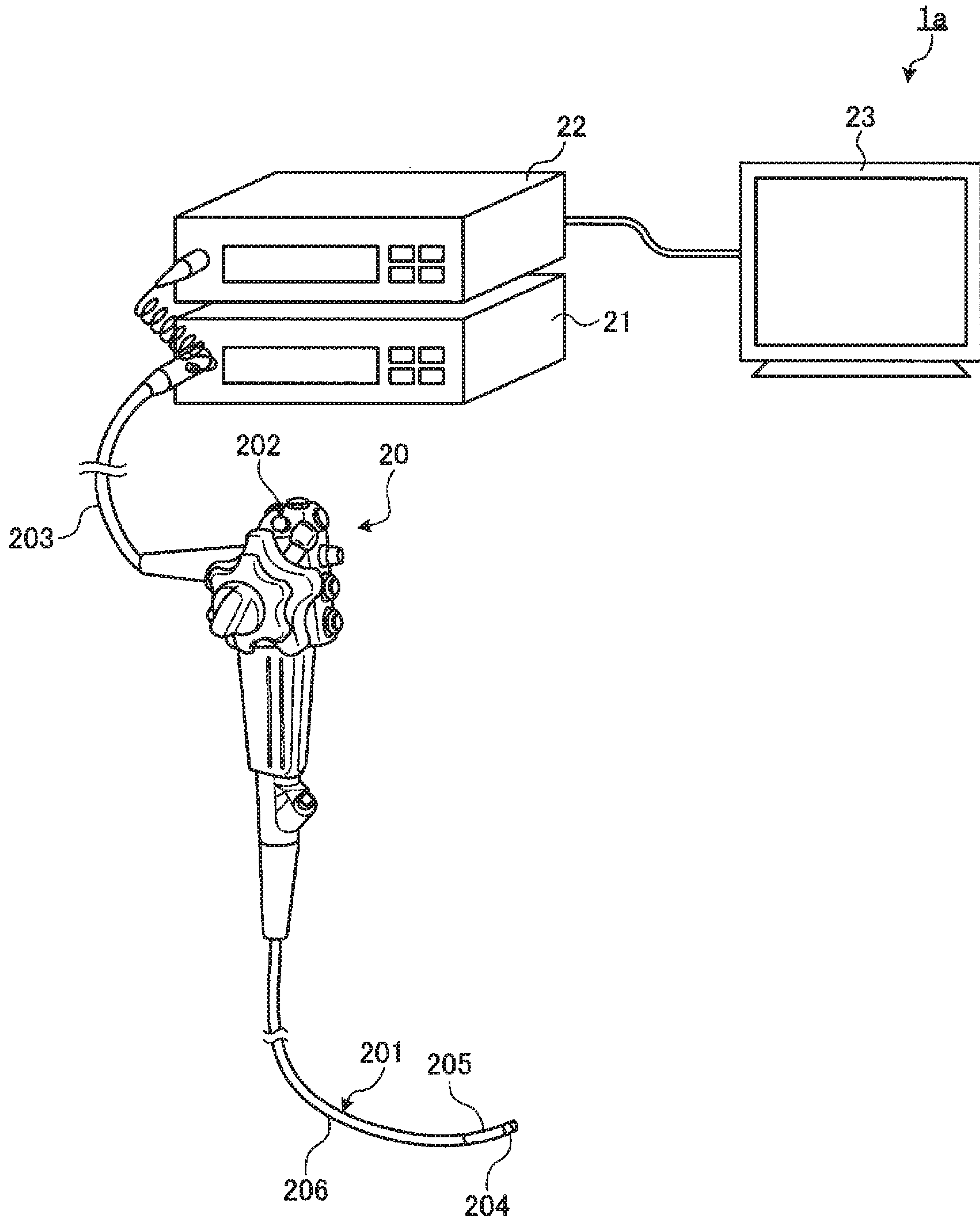


FIG. 8

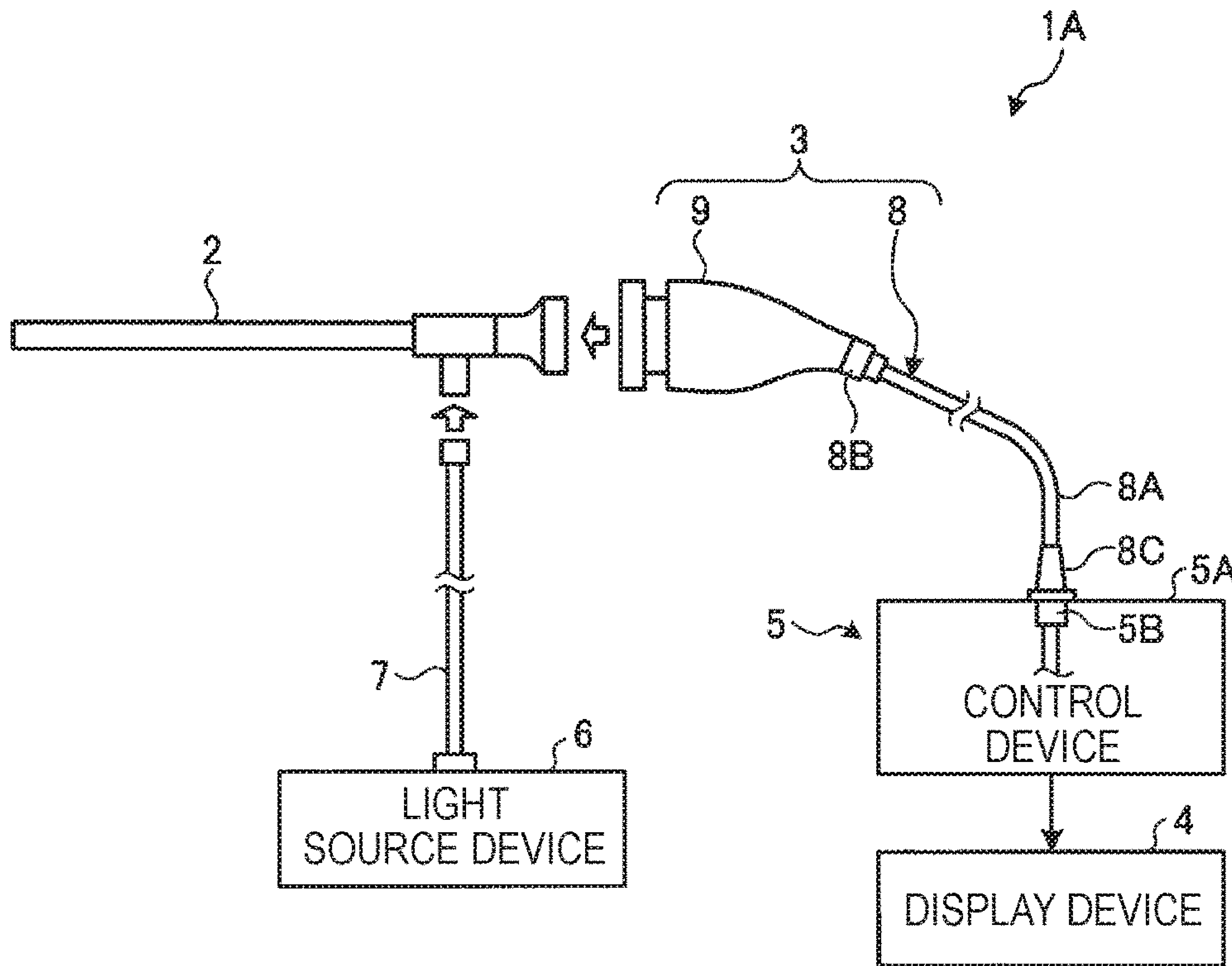
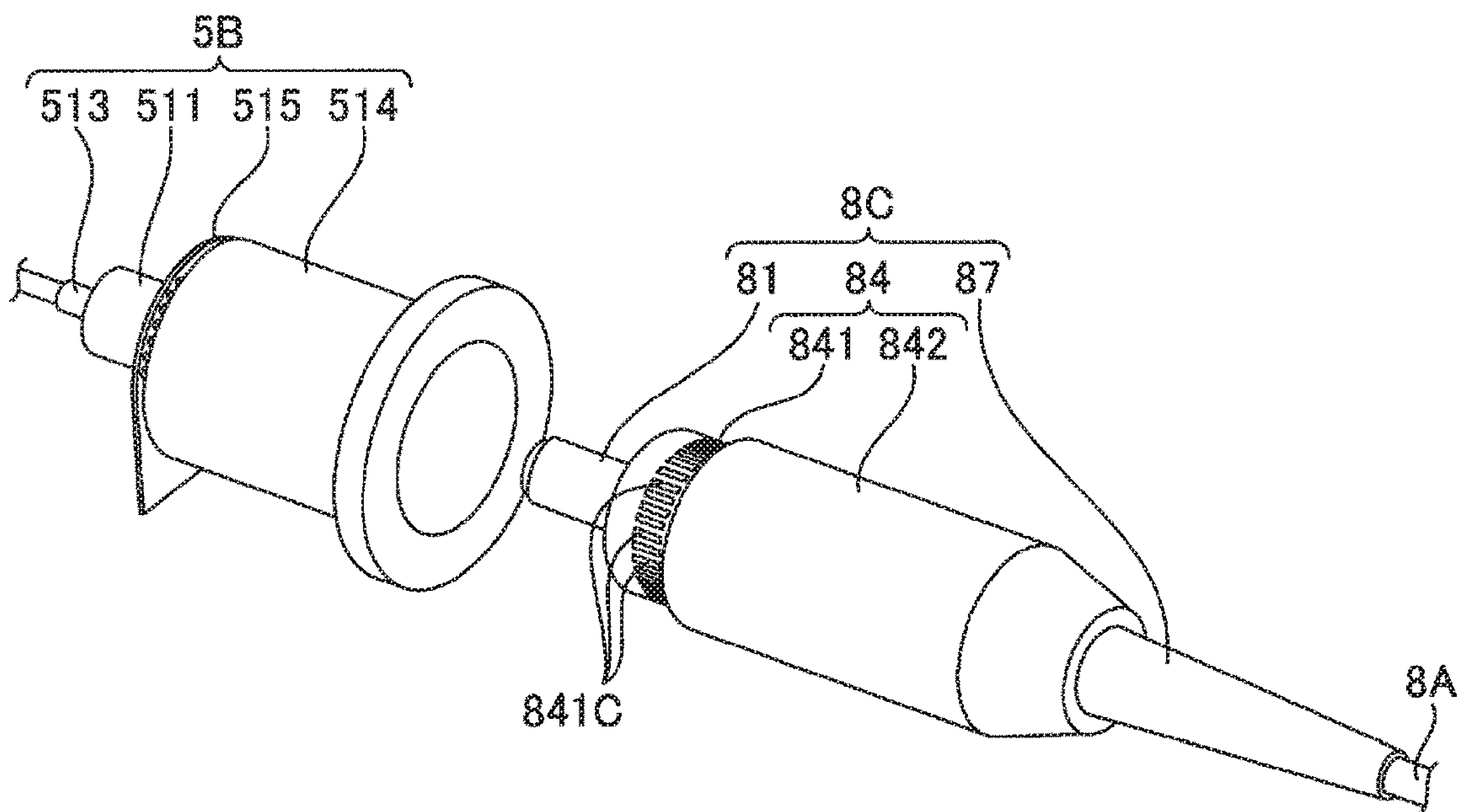


FIG. 9



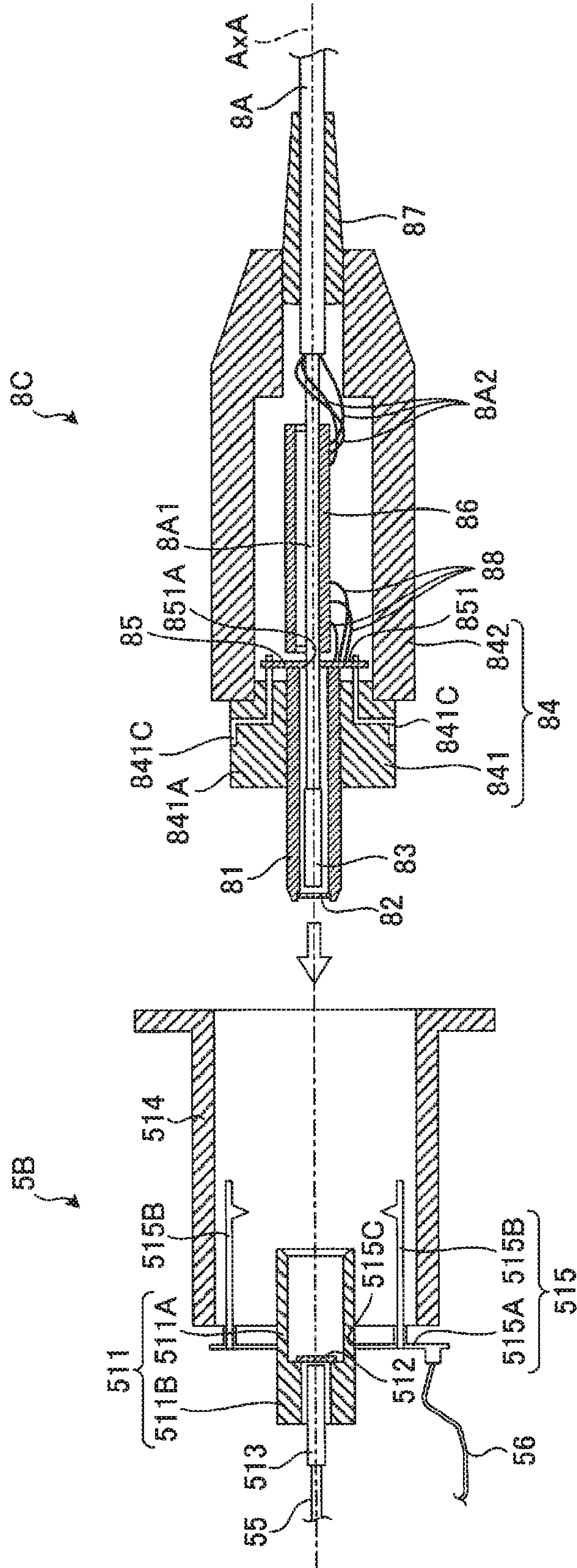


FIG. 10
8C
AxA
8A
87
8A2
86
8A1
851A
88
85
851
842
84
841C
841
841A
81
83
82
5B
514
515B
515C
515
511
511A
511B
512
515A
56
513
55

FIG. 11

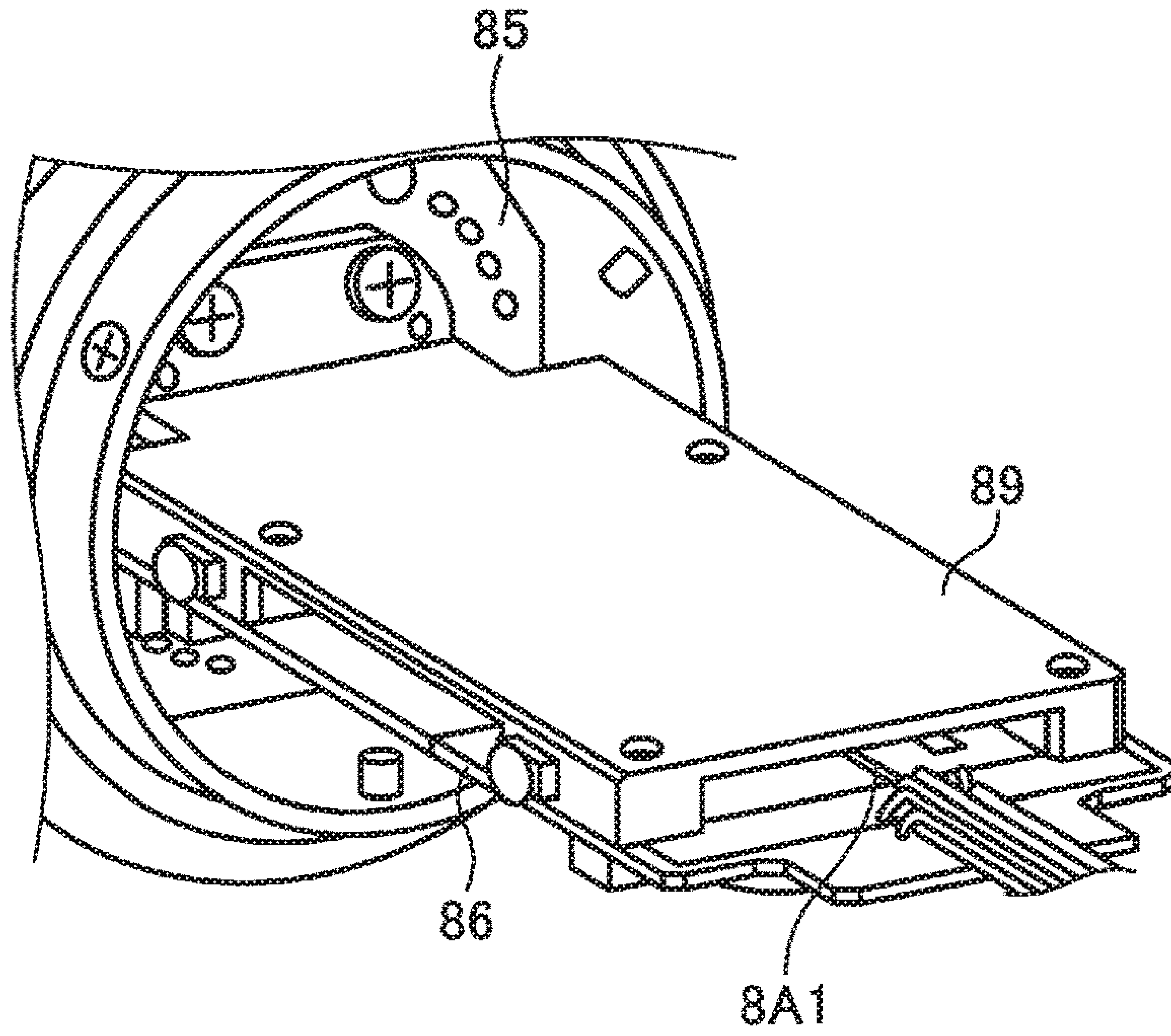
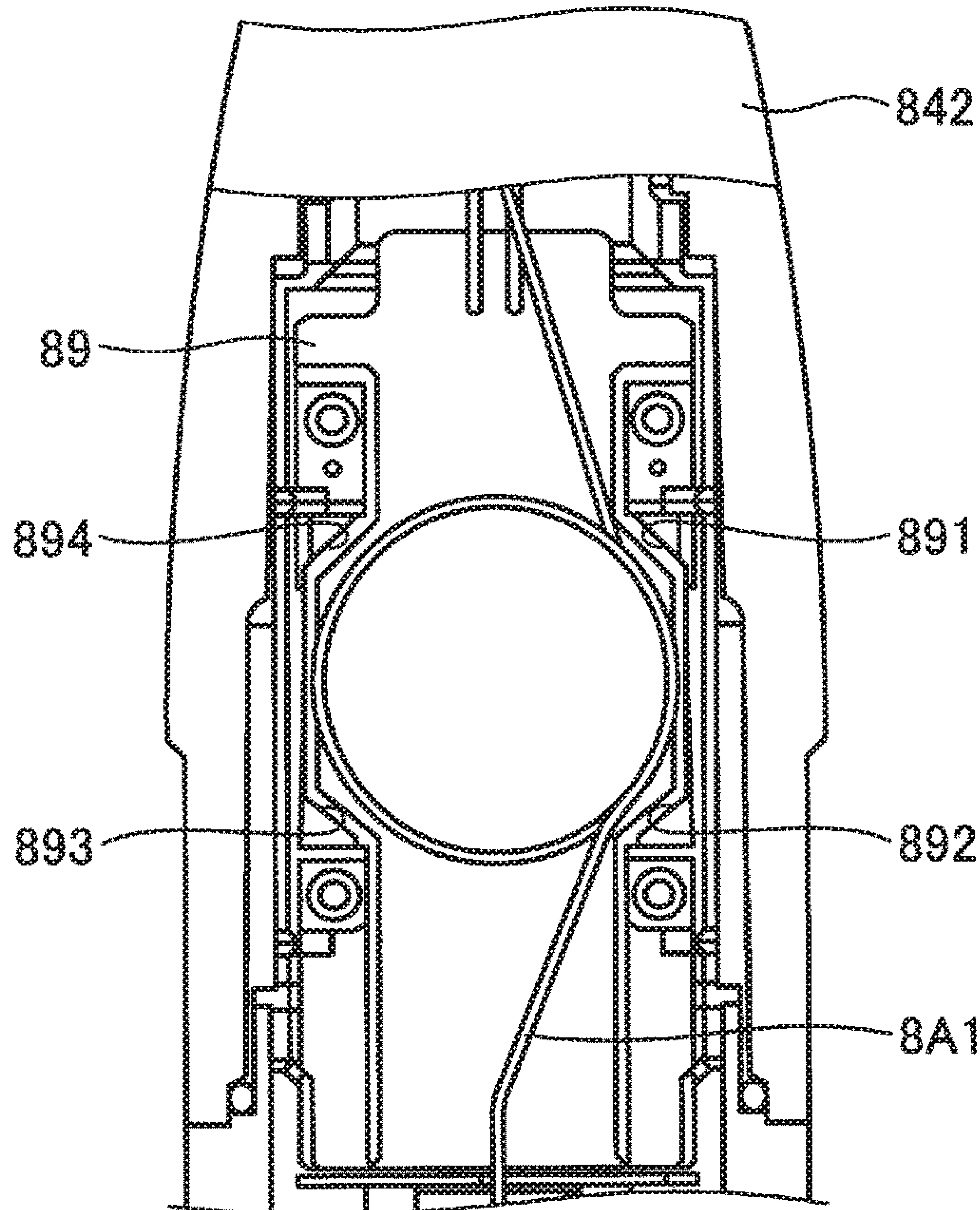


FIG. 12



ENDOSCOPIC DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 15/356,811, filed Nov. 21, 2016, which claims the benefit of Japanese Priority Patent Application JP 2015-248860, filed Dec. 21, 2015, the entire contents of each are incorporated herein by reference.

BACKGROUND

The present disclosure relates to an endoscopic device.

Heretofore, in the medical field, there are known endoscopic devices that use an image sensor to image the interior (the inside of the body) of a target of observation, such as a person, and enable observation of the inside of the body (see JP 2011-000346A, for example). The endoscopic device described in JP 2011-000346A is equipped with an image sensor that captures a subject image in which light has been condensed by an insertion section inserted inside the body, and a drive circuit board for driving the image sensor. In the endoscopic device, the relative positions of the image sensor and the drive circuit board are fixed by a spacer.

SUMMARY

Meanwhile, in some cases, the endoscopic device disclosed by JP 2011-000346A may be exposed to high temperature (120° C., for example) by a sterilization process, such as with an autoclave. In such cases, since components such as the image sensor, the drive circuit board, and the spacer provided in the endoscopic device are exposed to high temperature, each of these components undergoes thermal expansion. However, in JP 2011-000346A, this thermal expansion is not considered, and because of the respective stresses imparted to the joint interfaces with the spacer due to differences in the individual coefficients of thermal expansion, there is a risk of a faulty electrical connection occurring between the image sensor and the drive circuit board.

The present disclosure has been devised in light of the above, and provides an endoscopic device capable of making a reliable electrical connection between an image sensor and a substrate, even when exposed to high temperature.

According to an embodiment of the present disclosure, there is provided an endoscopic device, including: an image sensor section including an image sensor that senses and converts lights into an electrical signal; a substrate that is electrically connected to the image sensor section; and an intermediate unit, interposed between the image sensor section and the substrate, that electrically connects the image sensor section and the substrate.

The intermediate unit may include an intermediate member formed using a material having a coefficient of thermal expansion that is the same as a coefficient of thermal expansion of the image sensor section, or a coefficient of thermal expansion that is close to the coefficient of thermal expansion of the image sensor section from between the image sensor section and the substrate.

The intermediate unit may additionally include solder balls that electrically connect the intermediate member and the substrate, and underfill, provided between the intermediate member and the substrate, that secures the intermediate member and the substrate.

The endoscopic device may further include: solder balls that electrically connect the image sensor section and the intermediate member.

The intermediate unit may include an electrically conductive, elastically deformable elastic member provided between the image sensor section and the substrate.

The intermediate unit may include an intermediate member formed using a material having a coefficient of thermal expansion that is the same as a coefficient of thermal expansion of the image sensor section, or a coefficient of thermal expansion that is close to the coefficient of thermal expansion of the image sensor section from between the image sensor section and the substrate, and an electrically conductive elastic member, provided between the intermediate member and the substrate, that retractably connects the intermediate member and the substrate from one to the other.

According to an embodiment of the present disclosure, there is exhibited an advantageous effect of making a reliable electrical connection between an image sensor and a substrate, even when exposed to high temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram illustrating a schematic configuration of an endoscopic device according to Embodiment 1 of the present disclosure;

FIG. **2** is a block diagram illustrating a configuration of the camera head and the control device illustrated in FIG. **1**;

FIG. **3** is a schematic diagram explaining the major configuration of an imaging section according to Embodiment 1 of the present disclosure;

FIG. **4** is a schematic diagram explaining the major configuration of an imaging section according to Modification 1 of Embodiment 1 of the present disclosure;

FIG. **5** is a schematic diagram explaining the major configuration of an imaging section according to Modification 2 of Embodiment 1 of the present disclosure;

FIG. **6** is a schematic diagram explaining the major configuration of an imaging section according to Modification 3 of Embodiment 1 of the present disclosure;

FIG. **7** is a diagram illustrating a schematic configuration of an endoscopic device according to Embodiment 2 of the present disclosure;

FIG. **8** is a diagram illustrating a schematic configuration of an endoscopic device according to Embodiment 2 of the present disclosure;

FIG. **9** is an exploded perspective diagram of a plug and a receptacle as viewed from base end side (camera head side) of the plug;

FIG. **10** is a cross-section view cut along a plane passing through a central axis in the direction in which a plug and a receptacle connect;

FIG. **11** is a diagram illustrating a major configuration of an endoscopic device according to Embodiment 3 of the present disclosure; and

FIG. **12** is a diagram illustrating a major configuration of an endoscopic device according to Embodiment 3 of the present disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENT(S)

Hereinafter, embodiments for carrying out the present disclosure (hereinafter designated the exemplary embodiments) will be described. In the embodiments, an endoscopic device for medical use that captures and displays an interior image of a test subject such as a patient will be

described as an example of a medical image acquisition system including a medical imaging device according to an embodiment of the present disclosure. In addition, the present disclosure is not limited by these embodiments. Furthermore, in the description of the drawings, like portions are denoted by like signs.

Embodiment 1

FIG. **1** is a diagram illustrating a schematic configuration of an endoscopic device **1** according to Embodiment 1 of the present disclosure. The endoscopic device **1** is a device used in the medical field that enables one to observe a photographic subject of the interior (the inside of the body) of a target of observation, such as a person. As illustrated in FIG. **1**, the endoscopic device **1** is equipped with an endoscope **2**, an imaging device **3**, a display device **4**, a control device **5**, and a light source device **6**.

One end of a light guide **7** is connected to the endoscope **2**, and the light source device **6** supplies white illuminating light for illuminating the inside of the body to the one end of the light guide **7**. One end of the light guide **7** is removably connected to the light source device **6**, while the other end is removably connected to the endoscope **2**. Additionally, the light guide **7** transmits light supplied from the light source device **6** from the one end to the other end, thereby supplying the light to the endoscope **2**.

The imaging device **3** captures a subject image from the endoscope **2**, and outputs the imaging result. As illustrated in FIG. **1**, the imaging device **3** is equipped with a transmission cable **8** which acts as a signal transmission section, and a camera head **9**. In Embodiment 1, the medical imaging device is constituted by the transmission cable **8** and the camera head **9**.

The endoscope **2** has a rigid, long and narrow shape, and is inserted inside the body. Provided in the interior of the endoscope **2** is an optical system, which is made up of one or multiple lenses, and which condenses the light of the subject image. The endoscope **2** emits light supplied through the light guide **7** from the leading end, and irradiates the inside of the body. Additionally, the light radiated inside the body (that is, the subject image) is condensed by the optical system (lens unit **91**) inside the endoscope **2**.

The camera head **9** is removably connected to the base end of the endoscope **2**. Additionally, the camera head **9**, under control by the control device **5**, captures a subject image condensed by the endoscope **2**, and outputs an imaging signal according to the imaging. Note that the detailed configuration of the camera head **9** will be discussed later.

One end of the transmission cable **8** is removably connected to the control device **5** through a connector, while the other end is removably connected to the camera head **9** through a connector. Specifically, the transmission cable **8** is a cable in which multiple electrical wires (not illustrated) are arranged inside the inner part of an outer sheath that acts as the outermost layer. The multiple electrical wires are electrical wires for transmitting the imaging signal output from the camera head **9**, as well as a control signal, a synchronization signal, a clock, and power output from the control device **5** to the camera head **9**, respectively.

The display device **4**, under control by the control device **5**, displays an image generated by the control device **5**. The display device **4** preferably includes a display of at least 55 inches to achieve a sense of immersion more easily during observation, but is not limited thereto.

The control device **5** processes the imaging signal input from the camera head **9** through the transmission cable **8**, and outputs an image signal to the display device **4**. In addition, the control device **5** also centrally controls the operations of the camera head **9** and the display device **4**. Note that the detailed configuration of the control device **5** will be discussed later.

Next, a configuration of the imaging device **3** and the control device **5** will be described. FIG. **2** is a block diagram illustrating a configuration of the imaging device **3** and the control device **5**. Note that in FIG. **2**, the connector that allows the camera head **9** and the transmission cable **8** to be removably connected to each other is omitted from illustration.

Hereinafter, the configuration of the control device **5** and the configuration of the camera head **9** will be described in order. Note that in the following, the gist of the present disclosure is described primarily as the configuration of the control device **5**. As illustrated in FIG. **2**, the control device **5** is equipped with a signal processing section **51**, an image generation section **52**, a communication module **53**, an input section **54**, a control section **55**, and memory **56**. Note that the control device **5** may also be provided with components such as a power supply section (not illustrated) that generates a power supply voltage for driving the control device **5** and the camera head **9** and respectively supplies the power supply voltage to each component of the control device **5**, while also supplying the power supply voltage to the camera head **9** through the transmission cable **8**.

The signal processing section **51** performs signal processing such as noise removal, and if necessary, A/D conversion, on the imaging signal output by the camera head **9**, and outputs a digitized imaging signal (pulse signal) to the image generation section **52**.

Additionally, the signal processing section **51** generates a synchronization signal for the imaging device **3** and the control device **5**, and a clock. The synchronization signal for the imaging device **3** (such as a synchronization signal indicating the imaging timings of the camera head **9**, for example) and the clock (a clock used for serial communication, for example) are sent to the imaging device **3** on a line not illustrated, and the imaging device **3** drives on the basis of the synchronization signal and the clock.

The image generation section **52** generates a display image signal to be displayed by the display device **4**, based on the imaging signal input from the signal processing section **51**. The image generation section **52** executes certain signal processing on the imaging signal to generate a display image signal that includes the subject image. Herein, the image processing may be any of various types of image processing, such as interpolation processing, color correction processing, color enhancement processing, and edge enhancement processing. The image generation section **52** outputs the generated image signal to the display device **4**.

The communication module **53** outputs, to the imaging device **3**, a signal from the control device **5** including a control signal discussed later that is transmitted from the control section **55**. The communication module **53** also outputs a signal from the imaging device **3** to the control device **5**. In other words, the communication module **53** is a relay device that outputs the signals from the respective components of the control device **5** to the imaging device **3** in a collective manner, such as by parallel-serial conversion, for example, and also outputs a signal input from the imaging device **3** to the respective components of the control device **5** in a distributed manner, such as by serial-parallel conversion, for example.

The input section **54** is realized using a user interface such as a keyboard, a mouse, or a touch panel, and accepts the input of various information.

The control section **55** performs controls such as drive control of each component, including the control device **5** and the camera head **9**, and input/output control of information with respect to each component. The control section **55** generates a control signal by referencing communication information data recorded in the memory **56** (such as communication format information, for example), and transmits the generated control signal to the imaging device **3** through the communication module **53**. The control section **55** also outputs a control signal to the camera head **9** through the transmission cable **8**.

The memory **56** is realized using semiconductor memory such as flash memory or dynamic random access memory (DRAM), and records communication information data (such as communication format information, for example). Note that the memory **56** may also record information such as various programs executed by the control section **55**.

Note that the signal processing section **51** may also include an AF processing section that outputs a certain AF score value for each frame based on an input frame imaging signal, and an AF computation section that performs an AF computational process of selecting the frame or the focus lens position best suited as the focus position, based on the AF score value of each frame from the AF processing section.

Note that the signal processing section **51**, the image generation section **52**, the communication module **53**, and the control section **55** discussed above are realized by a general-purpose processor such as a central processing unit (CPU) including internal memory (not illustrated) in which a program is recorded, or by a special-purpose processor such as any of various types of computational circuits that execute a specific function, such as an application-specific integrated circuit (ASIC). Additionally, a field-programmable gate array (FPGA; not illustrated), which is a type of programmable integrated circuit, may also be used to realize the above. Note that in the case of using an FPGA, memory storing configuration data may be provided, and the FPGA, that is, the programmable integrated circuit, may be configured according to configuration data read out from the memory.

Next, the gist of the present disclosure will be described primarily as the configuration of the camera head **9**. As illustrated in FIG. **2**, the camera head **9** is equipped with a lens unit **91**, an imaging section **92**, a drive section **93**, a communication module **94**, and a camera head control section **95**.

The lens unit **91** is configured using one or multiple lenses, and forms a subject image condensed by the endoscope **2** onto the imaging surface of an image sensor constituting the imaging section **92**. The one or multiple lenses are movably configured along the optical axis. Additionally, the lens unit **91** is provided with a focus mechanism that moves the one or multiple lenses to vary an optical zoom mechanism (not illustrated) that varies the angle of view, or the focus point. Note that, besides the optical zoom mechanism and the focus mechanism, the lens unit **91** may also be provided with a diaphragm mechanism, or an optical filter (for example, a filter that cuts infrared light) that may be freely inserted or removed from the optical axis.

The imaging section **92** images a subject, under control by the camera head control section **95**. The imaging section **92** includes an image sensor made of a device such as a charge-coupled device (CCD) or a complementary metal-oxide-semiconductor (CMOS) that senses the light of a subject image formed by the lens unit **91**, and converts the light into an electrical signal. In the CCD case, for example, a signal processing section (not illustrated) that performs signal processing (such as A/D conversion) on the electrical signal (analog signal) from the image sensor and outputs an imaging signal is implemented in a sensor chip or the like. In the CMOS case, for example, a signal processing section that performs signal processing (such as A/D conversion) on an (analog) electrical signal converted from light into an electrical signal and outputs an imaging signal is included in the image sensor.

FIG. **3** is a schematic diagram explaining the major configuration of the imaging section **92**. As illustrated in FIG. **3**, the imaging section **92** includes an image sensor **101**, a holding unit **102**, an intermediate unit **103**, a land grid array (LGA) **104**, and a substrate **110**. A lens adapter **120** is provided on the holding unit **102**, and the imaging section **92** is attached to the lens unit **91** by the lens adapter **120**. In the imaging section **92**, observational light from outside the lens unit **91** is incident on the image sensor **101** through the lens unit **91**. In Embodiment 1, the substrate **110** is taken to be formed using an organic material having a coefficient of thermal expansion from 12 ppm/° C. to 40 ppm/° C. in the direction along the mounting face at room temperature. In Embodiment 1, an image sensor section **100** is constituted by the image sensor **101** and the holding unit **102**.

The image sensor **101** is realized using the CCD or CMOS discussed above. In the image sensor **101**, multiple pixels that sense light from the lens unit **91** are arranged in a two-dimensional grid (arranged in a matrix). Additionally, the image sensor **101** generates an electrical signal (also called an image signal or the like) by performing photoelectric conversion on the light sensed by each of the pixels.

The image sensor **101** is electrically connected to the substrate **110**, and includes a built-in circuit section that transmits and receives signals to and from the substrate **110**.

The holding unit **102** forms a housing that holds the image sensor **101** inside. The holding unit **102** includes a holding section **102*a***, a ring section **102*b***, and a cap section **102*c***.

The holding section **102*a*** forms a tube with a floor on one end, and holds the image sensor **101** in the floor section. The holding section **102*a*** has a smaller coefficient of thermal expansion than the substrate **110**, and is formed using a ceramic having a coefficient of thermal expansion from 4 ppm/° C. to 11 ppm/° C. in the direction along the mounting face at room temperature, for example.

The holding unit **102** forms a ring extending from open end of the holding section **102*a***. The ring section **102*b*** is formed using a resin such as plastic, for example.

The cap section **102*c*** has a plate-like shape, and is provided on the edge of the ring section **102*b*** on the opposite side from the holding section **102*a***. With the cap section **102*c***, the opening in the floored tube formed by the holding section **102*a*** and the ring section **102*b*** is sealed. The cap section **102*c*** is formed using an optically transparent material, such as glass, for example.

Note that in Embodiment 1, the image sensor section **100** is constituted by the image sensor **101** and the holding unit **102**, but the configuration is not limited thereto, and the image sensor section **100** may also be constituted by the image sensor **101** only, for example.

The intermediate unit **103** is provided between the image sensor section **100** and the substrate **110**. The intermediate unit **103** includes an intermediate member **103*a***, solder balls **103*b***, and underfill **103*c***.

The intermediate member **103***a* is provided internally with electrical interconnects, enabling an electrical connection between the image sensor **101** and the substrate **110**. The intermediate member **103***a* may be a circuit board using a material such as ceramic, silicon, glass, or glass fiber reinforced epoxy resin as a substrate, for example, but is not limited thereto. The intermediate member **103***a* is formed using a material having the same coefficient of thermal expansion as the image sensor section **100**, or a material having a coefficient of thermal expansion that is close to the image sensor section **100** from between the image sensor section **100** and the substrate **110**. Specifically, the intermediate member **103***a* is formed using a material having a coefficient of thermal expansion whose value is 95% or greater than the coefficient of thermal expansion of the holding section **102***a*, and also less than or equal to an intermediate value between the coefficient of thermal expansion of the holding section **102***a* and the coefficient of thermal expansion of the substrate **110**.

The solder balls **103***b* are provided between the intermediate member **103***a* and the substrate **110**. The solder balls **103***b* transmit signals from the substrate **110** to the intermediate member **103***a*, and also transmit signals from the intermediate member **103***a* to the substrate **110**.

The underfill **103***c* surrounds the solder balls **103***b* and fills in the space between the intermediate member **103***a* and the substrate **110**, and preferably fills in the space to cover the solder balls **103***b* without gaps, but is not limited thereto. The underfill **103***c* is a material with less elasticity than the intermediate member **103***a* and the substrate **110**. The underfill **103***c* preferably is a material having a glass transition temperature of 120° C. or more, but is not limited thereto. The underfill **103***c* is formed using a material having a coefficient of thermal expansion from 30 ppm/° C. to 50 ppm/° C. at room temperature after hardening, for example. The underfill **103***c* fixes the intermediate member **103***a* and the substrate **110** in place, and in addition, by surrounding the solder balls **103***b*, reduces corrosion of the solder balls **103***b*. Note that the underfill **103***c* may also be formed using a material having a coefficient of thermal expansion with a value between the coefficient of thermal expansion of the intermediate member **103***a* and the coefficient of thermal expansion of the substrate **110**.

The land grid array (LGA) **104** is realized using multiple flat electrode pads that electrically connect the image sensor section **100** and the intermediate unit **103**. The drive section **93** includes a driver that, under control by the camera head control section **95**, causes the optical zoom mechanism and the focus mechanism to operate, and varies the angle of view and the focus position of the lens unit **91**.

The communication module **94** outputs signals transmitted from the control device **5** to respective components inside the camera head **9**, such as the camera head control section **95**. Additionally, the communication module **94** converts information related to the current state of the camera head **9** and the like into a signal format according to a predetermined transmission scheme, and outputs the converted signal to the control device **5** through the transmission cable **8**. In other words, the communication module **94** is a relay device that outputs a signal input from the control device **5** and the transmission cable **8** to respective components of the camera head **9** in a distributed manner, such as by serial-parallel conversion, for example, and also outputs signals from the respective components of the camera head **9** to the control device **5** and the transmission cable **8** in a collective manner, such as by parallel-serial conversion, for example.

The camera head control section **95** controls the operation of the camera head **9** overall, according to signals such as a drive signal input through the transmission cable **8**, or an instruction signal output from an operating section by a user operation on the operating section, such as a switch provided exposed on the outer face of the camera head **9**. Additionally, the camera head control section **95** outputs information related to the current state of the camera head **9** to the control device **5** through the transmission cable **8**.

Note that the drive section **93**, the communication module **94**, and the camera head control section **95** discussed above are realized by a general-purpose processor such as a central processing unit (CPU) including internal memory (not illustrated) in which a program is recorded, or by a special-purpose processor such as any of various types of computational circuits that execute a specific function, such as an application-specific integrated circuit (ASIC). Additionally, an FPGA, which is a type of programmable integrated circuit, may also be used to realize the above. Note that in the case of using an FPGA, memory storing configuration data may be provided, and the FPGA, that is, the programmable integrated circuit, may be configured according to configuration data read out from the memory.

Note that the camera head **9** or the transmission cable **8** may also include a signal processing section that performs signal processing on an imaging signal generated by the communication module **94** or the imaging section **92**. Additionally, based on a reference clock generated by an oscillator (not illustrated) provided inside the camera head **9**, an imaging clock for driving the imaging section **92** and a driving clock for driving the drive section **93** may be generated and output to the imaging section **92** and the drive section **93**, respectively. Furthermore, based on a synchronization signal input from the control device **5** through the transmission cable **8**, timing signals for various processes in the imaging section **92**, the drive section **93**, and the camera head control section **95** may be generated and output to the imaging section **92**, the drive section **93**, and the camera head control section **95**, respectively. Also, the camera head control section **95** may be provided not in the camera head **9**, but instead in the transmission cable **8** or the control device **5**.

In the endoscopic device **1** having the configuration described above, since the intermediate unit **103** is provided between the image sensor section **100** (holding section **102***a*) and the substrate **110**, when exposed to high temperature (for example, 120° C.) by a sterilization process, such as with an autoclave, the stress due to deformation of the substrate **110** by thermal expansion (thermal strain) is kept from spreading from the substrate **110** to the holding section **102***a*. Specifically, the stress due to the thermal expansion of the substrate **110** spreads to the underfill **103***c* of the intermediate unit **103**, but is absorbed by deformation of the underfill **103***c*. Moreover, since the coefficient of thermal expansion of the intermediate member **103***a* is the same or close to that of the holding section **102***a*, little to no stress is transmitted to the holding section **102***a* side. For this reason, the holding section **102***a* is able to make a reliable electrical connection between the substrate **110** and the image sensor **101**, without the connection to the intermediate member **103***a* (the joined state provided by the LGA **104**) being broken by stress arising in the substrate **110**. Likewise, deformation due to thermal expansion of the image sensor section **100** (holding section **102***a*) similarly is kept from spreading to the substrate **110**. In contrast, in JP 2011-000346A, this thermal expansion is not considered, and stress from the substrate (drive circuit board) is imparted to

the joint interface with the spacer and the image sensor, thereby producing a faulty electrical connection with the image sensor.

According to Embodiment 1 discussed above, the intermediate unit **103** is provided between the holding unit **102** that holds the image sensor **101**, and the substrate **110**, and the intermediate member **103***a* included in the intermediate unit **103** is formed with a material having approximately the same coefficient of thermal expansion as the holding section **102***a* of the holding unit **102**. Consequently, even when exposed to high temperature (for example, 120° C.) by a sterilization process, such as with an autoclave, the stress due to deformation of the substrate **110** by thermal expansion is kept from spreading from the substrate **110** to the holding section **102***a*. Thus, a reliable electrical connection may be made between the image sensor **101** and the substrate **110**, even when exposed to high temperature.

In addition, according to Embodiment 1 above, since the connection structure between the holding unit **102** and the intermediate unit **103** is an LGA structure, the gap between the holding unit **102** and the intermediate unit **103** may be reduced, and the configuration of the imaging section **92** may be made thinner.

Additionally, according to Embodiment 1 above, since the electrical connection between the intermediate member **103***a* and the substrate **110** is made with a ball grid array (BGA) structure using the solder balls **103***b*, compared to the case of using an LGA structure, for example, the gap between the intermediate member **103***a* and the substrate **110** may be increased, thereby increasing the volume in which the underfill **103***c* is used, and making it possible to improve workability related to the filling of the underfill **103***c* and the like, while also obtaining even more reliably the stress-absorbing advantages provided by the underfill **103***c*. For example, when using the solder balls **103***b*, the distance between the intermediate member **103***a* and the substrate **110** is 400 μm, whereas when using an LGA structure, the distance between the intermediate member **103***a* and the substrate **110** is approximately 40 μm.

Also, according to Embodiment 1 above, since the intermediate member **103***a* is provided between the image sensor section **100** and the substrate **110**, compared to the case of directly joining the image sensor section **100** and the substrate **110**, the interval between the image sensor section **100** and the substrate **110** becomes larger, and the workability related to the assembly of the imaging section **92** may be improved. A lens adapter **120** larger than the image sensor section **100** sometimes is affixed to the image sensor section **100** with a thermosetting resin or the like, and the view between the image sensor section **100** and the substrate **110** may become narrow in some cases, but by providing the intermediate member **103***a*, the interval between the image sensor section **100** and the substrate **110** is increased, thereby ensuring the view and improving workability.

Modification 1 of Embodiment 1

Next, Modification 1 of Embodiment 1 of the present disclosure will be described. FIG. **4** is a schematic diagram explaining the major configuration of an imaging section according to Modification 1 of Embodiment 1 of the present disclosure. In Embodiment 1 above, the holding section **102***a* and the intermediate unit **103** are described as being connected electrically by the LGA **104**, but in this modification, the holding section **102***a* and the intermediate unit **103** are connected electrically by solder balls.

In this modification, the configuration of the imaging section **92** discussed earlier is provided with a ball grid array (BGA) **104**A instead of the LGA **104**. The BGA **104**A is realized using multiple globular electrodes (solder balls) that electrically connect the holding unit **102** and the intermediate unit **103**.

Note that the solder balls used for the BGA **104**A and the solder balls **103***b* discussed earlier may be made of solder only, but may also be solder balls including a different material, such as copper-core solder balls, in which copper is provided in the core, or resin-core solder balls, in which resin is provided in the core, for example. Note that to decrease faulty electrical connections due to a difference in the coefficient of thermal expansion between the image sensor section **100** (holding section **102***a*) and the substrate **110**, it is preferable to use resin-core solder balls for the BGA **104**A and/or the solder balls **103***b*.

Additionally, underfill similar to the underfill **103***c* of the intermediate unit **103** may also be used to fill in the BGA **104**A, or in other words, the space between the image sensor section **100** and the intermediate unit **103**.

According to Modification 1, similarly to Embodiment 1 discussed above, the intermediate unit **103** is provided between the holding unit **102** that holds the image sensor **101**, and the substrate **110**, and the intermediate member **103***a* included in the intermediate unit **103** is formed with a material having approximately the same coefficient of thermal expansion as the holding section **102***a* of the holding unit **102**. Consequently, even when exposed to high temperature (for example, 120° C.) by a sterilization process, such as with an autoclave, the stress due to deformation of the substrate **110** by thermal expansion is kept from spreading from the substrate **110** to the holding section **102***a*. Thus, a reliable electrical connection may be made between the image sensor **101** and the substrate **110**, even when exposed to high temperature.

Additionally, according to Modification 1, since the BGA **104**A is provided between the image sensor section **100** and the substrate **110**, the gap between the image sensor section **100** and the substrate **110** becomes even larger compared to the LGA **104**, and the workability related to the assembly of the imaging section **92** may be improved.

Modification 2 of Embodiment 1

Next, Modification 2 of Embodiment 1 of the present disclosure will be described. FIG. **5** is a schematic diagram explaining the major configuration of an imaging unit according to Modification 2 of Embodiment 1 of the present disclosure. In Embodiment 1 above, the intermediate unit **103** is described as including the intermediate member **103***a*, the solder balls **103***b*, and the underfill **103***c*, and is described as electrically connecting the image sensor section **100** and the substrate **110** with the intermediate member **103***a* and the solder balls **103***b*, while also using the underfill **103***c* to keep stress from the substrate **110** from being transmitted to the image sensor section **100**. However, in Modification 2, an elastic member **103***f* is used to electrically connect the image sensor section **100** and the substrate **110** as well as keep stress from the substrate **110** from being transmitted to the image sensor section **100**.

In Modification 2, the configuration of the imaging section **92** discussed earlier is provided with an intermediate unit **103**A instead of the intermediate unit **103** and the LGA **104**, and also is provided with a holding unit **130** that holds the lens unit **91** while also supporting the lens adapter **120**

and the substrate **110**. The lens adapter **120** is attached to the holding unit **130** by screws B**1** and B**2**.

The intermediate unit **103**A includes first electrode pads **103***d* that electrically connect to the image sensor section **100**, specifically the circuit (electrodes) of the holding section **102***a*, second electrode pads **103***e* that electrically connect to the circuit (electrodes) of the substrate **110**, and an elastic member **103***f* allowing electrical connection between the first electrode pads **103***d* and the second electrode pads **103***e*, while also being elastically deformable. The elastic member **103***f* is formed using a conductive material, such as a conductive metal or alloy, for example, and is formed by curving a belt-shaped member. Note that the elastic member **103***f* is not limited to the above insofar as the elastic member **103***f* is conductive and elastic, and may also be a conductive coil spring, for example.

The holding unit **130** holds the lens unit **91**, and includes a holding section **131** that holds the lens adapter **120** via screws B**1** and B**2**, and multiple support members **132** provided between the holding section **131** and the substrate **110** that support the substrate **110** with respect to the holding unit **130**. The support members **132** are attached to the substrate **110** by screws B**3** and B**4**.

In the endoscopic device having the configuration described above, since the intermediate unit **103**A including the conductive elastic member **103***f* is provided between the holding unit **102** that holds the image sensor **101** and the substrate **110**, when exposed to high temperature (for example, 120° C.) by a sterilization process, such as with an autoclave, the stress due to deformation of the substrate **110** by thermal expansion is kept from spreading from the substrate **110** to the holding section **102***a*. Specifically, the stress produced by the thermal expansion of the substrate **110** is absorbed by elastic deformation of the elastic member **103***f* of the intermediate unit **103**A, with little to no stress being transmitted to the holding section **102***a* side. For this reason, the holding section **102***a* is able to make a reliable electrical connection between the substrate **110** and the image sensor **101**, without the connection to the intermediate unit **103**A being broken by stress from the substrate **110**.

According to Modification 2, the elastic member **103***f* having conductive and elastic properties is provided between the holding unit **102** that holds the image sensor **101**, and the substrate **110**, thereby electrically connecting the image sensor section **100** and the substrate **110** while also keeping stress from the substrate **110** from being transmitted to the image sensor section **100**. Thus, a reliable electrical connection between the image sensor **101** and the substrate **110** may be made, even when exposed to high temperature.

Modification 3 of Embodiment 1

Next, Modification 3 of Embodiment 1 of the present disclosure will be described. FIG. **6** is a schematic diagram explaining the major configuration of an imaging unit according to Modification 3 of Embodiment 1 of the present disclosure. In Modification 2 above, the intermediate unit **103**A is described as including the first electrode pads **103***d*, the second electrode pads **103***e*, and the elastic member **103***f*, but in Modification 2, an intermediate member **103***g* is provided in addition to the configuration of the intermediate unit **103**A.

In Modification 3, the configuration of the imaging section **92** discussed earlier is provided with an intermediate unit **103**B instead of the intermediate unit **103**A. The intermediate unit **103**B includes the first electrode pads **103***d*, the second electrode pads **103***e*, and the elastic member **103***f* discussed above, as well as an intermediate member **103***g*.

The intermediate member **103***g*, similarly to the intermediate member **103***a* discussed earlier, is provided internally with electrical interconnects, enabling an electrical connection between the image sensor **101** and the substrate **110**. The intermediate member **103***g* is formed using a material having a glass transition temperature of 120° C. or more, and the same coefficient of thermal expansion as the image sensor section **100**, or a coefficient of thermal expansion that is close to the image sensor section **100** from between the image sensor section **100** and the substrate **110**. Specifically, the intermediate member **103***g* is formed using a material having a coefficient of thermal expansion whose value is 95% or greater than the coefficient of thermal expansion of the holding section **102***a*, and also less than or equal to an intermediate value between the coefficient of thermal expansion of the holding section **102***a* and the coefficient of thermal expansion of the substrate **110**.

The holding unit **130** holds the lens unit **91**, and includes a holding section **131** that holds the lens adapter **120** via screws B**1** and B**2**, and multiple support members **132** provided between the holding section **131** and the substrate **110** that support the substrate **110** with respect to the holding unit **130**. The support members **132** are attached to the substrate **110** by screws B**3** and B**4**.

In the endoscopic device having the configuration described above, since the intermediate unit **103**B including the conductive elastic member **103***f* is provided between the holding unit **102** that holds the image sensor **101** and the substrate **110**, when exposed to high temperature (for example, 120° C.) by a sterilization process, such as with an autoclave, the stress due to deformation of the substrate **110** by thermal expansion is kept from spreading from the substrate **110** to the holding section **102***a*. Specifically, the stress produced by the thermal expansion of the substrate **110** is absorbed by elastic deformation of the elastic member **103***f* of the intermediate unit **103**B, with little to no stress being transmitted to the holding section **102***a* side. For this reason, the holding section **102***a* is able to make a reliable electrical connection between the substrate **110** and the image sensor **101**, without the connection to the intermediate unit **103**B (the joined state provided by the LGA **104**) being broken by stress from the substrate **110**.

According to Modification 3, the elastic member **103***f* having conductive and elastic properties is provided between the holding unit **102** that holds the image sensor **101**, and the substrate **110**, thereby electrically connecting the image sensor section **100** and the substrate **110** while also keeping stress from the substrate **110** from being transmitted to the image sensor section **100**. Thus, a reliable electrical connection between the image sensor **101** and the substrate **110** may be made, even when exposed to high temperature.

Embodiment 2

Next, Embodiment 2 of the present disclosure will be described. FIG. **7** is a diagram illustrating a schematic configuration of an endoscopic device **1***a* according to Embodiment 2 of the present disclosure. Embodiment 1 above describes an endoscopic device **1** using a rigid scope as the endoscope **2**, but the configuration is not limited thereto, and an endoscopic device using a flexible scope as the endoscope **2** is also acceptable. Embodiment 2 describes

an example of a case in which an imaging section is provided on the leading end of the insertion section of a flexible endoscope.

The endoscopic device **1***a* is equipped with an endoscope **20** that, by inserting an insertion section **201** inside a test subject's body, captures an internal image of an observation site and generates an electrical signal, a light source device **21** that produces illuminating light that radiates from the leading end of the endoscope **20**, a control device **22** that performs certain image processing on the electrical signal acquired by the endoscope **20** and also centrally controls the operations of the endoscopic device **1***a* as a whole, and a display device **23** that displays an internal image processed by the control device **22**. The endoscopic device **1***a* inserts the insertion section **201** inside the body of a test subject, such as a patient, and acquires an internal image of the inside of the test subject's body.

The endoscope **20** is equipped with a flexible insertion section **201** having a long and narrow shape, an operating section **202**, connected to the base end side of the insertion section **201**, that accepts the input of various operation signals, and a universal cord **203** which extends from the operating section **202** in a different direction from the direction in which the insertion section **201** extends, and which houses various cables that connect to the light source device **21** and the control device **22**.

The insertion section **201** includes a leading end section **204** that houses the imaging section **92** according to Embodiment 1 discussed earlier, a freely bendable curved section **205** made up of multiple curve joints, and a flexible tube section **206** connected to the base end side of the curved section **205** and having a flexible elongated shape.

Likewise in the endoscopic device **1***a* having the above configuration, and similarly to the endoscopic device **1** discussed earlier, if the imaging section **92** is provided in the leading end section **204**, even when exposed to high temperature (for example, 120° C.) by a sterilization process, such as with an autoclave, the stress due to deformation of the substrate **110** by thermal expansion is kept from spreading from the substrate **110** to the holding section **102***a*. Thus, a reliable electrical connection may be made between the image sensor **101** and the substrate **110**, even when exposed to high temperature.

Embodiment 3

Next, Embodiment 3 of the present disclosure will be described. In Embodiment 1, the exchange of electrical signals, the supply of power, the connection to ground, and the like between the camera head **9** and the control device **5** are conducted by multiple electrical interconnects provided in the transmission cable **8**, but in Embodiment 3, an optical signal is used for at least some signals transmitted and received between the camera head **9** and the control device **5**, such as an imaging signal transmitted from the camera head **9** to the control device **5**, for example.

FIG. **8** is a diagram illustrating a schematic configuration of an endoscopic device **1**A according to Embodiment 3 of the present disclosure. FIG. **9** is an exploded perspective view of a plug **8**C and a receptacle **5**B to be discussed later, as viewed from the base end side (camera head **9** side) of the plug **8**C. FIG. **10** is a cross-section view cut along a plane passing through a central axis A×A in the direction in which the plug **8**C and the receptacle **5**B connect. Structural elements which are the same as structural elements discussed earlier will be denoted with the same signs. The endoscopic device **1**A is equipped with an endoscope **2**, an imaging device **3**, a display device **4**, a control device **5**, and a light source device **6**. The imaging device **3** is equipped with a transmission cable **8** and a camera head **9**.

The transmission cable **8** is equipped with a cable section **8**A, a connector **8**B, and a plug **8**C. The cable section **8**A is a composite cable including, inside the inner part of an outer sheath (not illustrated) that acts as the outermost layer, an optical fiber **8A1**, which is an optical transmission line that transmits optical signals such as imaging signals, for example, and multiple electrical cables **8A2**, which are used to transmit and receive other electrical signals, supply power, connect to ground, and the like. Additionally, one end of the cable section **8**A is connected to the camera head **9** through the connector **8**B.

The plug **8**C is a male connector, and corresponds to an optical connector according to an embodiment of the present disclosure. Additionally, the plug **8**C is attached to the other end of the cable section **8**A.

The receptacle **5**B is a female connector provided on a housing **5**A of the control device **5**, and corresponds to an opposite connector.

By connecting the above plug **8**C and the receptacle **5**B to each other, the imaging device **3** and the control device **5** become connected both optically and electrically, thereby enabling the exchange of optical signals and electrical signals, the supply of power, and the connection to ground.

Next, the configuration of the plug **8**C and the receptacle **5**B will be described. The plug **8**C is equipped with a plug-side first outer edge **81**, a plug-side cover member **82**, a plug-side collimator **83**, a plug-side second outer edge **84**, a connector section **85**, a plug-side printed circuit board **86**, and an elastic member **87**.

As illustrated in FIGS. **9** and **10**, the plug-side first outer edge **81** has an approximately cylindrical tube shape. Note that the plug-side first outer edge **81** is tubular, but is not limited to being cylindrical, and may also be configured as a tube having an elliptical, square, polygonal, or some other cross-sectional shape. Additionally, an optical fiber **8A1** constituting the cable section **8**A is inserted through the plug-side first outer edge **81** inside the tube of the plug-side first outer edge **81**, and the plug-side first outer edge **81** covers the light-emitting end of the optical fiber **8A1** from which an optical signal is emitted.

The plug-side cover member **82** is provided to cover the tube of the plug-side first outer edge **81**, and is formed in a plate-like shape from a material that transmits light. The plug-side cover member **82** is joined airtight to the plug-side first outer edge **81** by soldering, brazing, or glass encapsulation. By sealing the leading end side of the plug-side first outer edge **81** with the plug-side cover member **82**, the intrusion of liquid or foreign matter inside the plug-side first outer edge **81** may be restrained, and reliability of optical communication may be ensured.

The plug-side cover member **82** is positioned at a position retracted from the leading end of the plug-side first outer edge **81** toward the base end side of the plug-side first outer edge **81** (a position set back from the leading end). For this reason, the plug-side cover member **82** is structured to be less likely touched by hand, and the adhesion of foreign matter onto the plug-side cover member **82** may be restrained. In other words, the reliability of optical communication is not impaired by such foreign matter.

As illustrated in FIG. **10**, the plug-side collimator **83** is disposed in a state joined to the light-emitting end of the optical fiber **8A1** inside the plug-side first outer edge **81**. In other words, the plug-side collimator **83** is disposed between the plug-side cover member **82** and the light-emitting end of

the optical fiber **8A1**. Additionally, the plug-side collimator **83** collimates the light (optical signal) emitted from the light-emitting end of the optical fiber **8A1**.

In the case of disposing the plug-side collimator **83**, the mechanical connection with the receptacle **5**B does not have to be as precise compared to a configuration that omits the plug-side collimator **83**, thereby making fabrication of the plug **8**C easier.

As illustrated in FIG. **10**, the plug-side second outer edge **84** is equipped with a leading end side outer edge **841** and a base end side outer edge **842**, and has an approximately cylindrical shape. Note that the plug-side second outer edge **84** is tubular, but is not limited to being cylindrical, and may also be configured as a tube having an elliptical, square, polygonal, or some other cross-sectional shape.

The leading end side outer edge **841** is provided with a base section **841**A made from a non-conductive material, and multiple plug-side electrical contact points **841**C made from a conductive material. As illustrated in FIG. **10**, the plug-side electrical contact points **841**C are provided partially exposed on the outer circumferential surface of the base section **841**A. The multiple plug-side electrical contact points **841**C are arranged at a certain interval in the circumferential direction of the leading end side outer edge **841**.

In addition, the base end portion of the plug-side first outer edge **81** fits into the leading end side outer edge **841** so that the leading end portion of the plug-side first outer edge **81** projects outward. At this point, the space between the leading end side outer edge **841** and the plug-side first outer edge **81** is sealed with an O-ring, or with an adhesive sealant such as silicon resin or epoxy resin.

The base end side outer edge **842** is disposed on the base end side with respect to the leading end side outer edge **841**. Additionally, the leading end portion of the base end side outer edge **842** fits against the base end side of the leading end side outer edge **841**, with the cable section **8**A internally inserted therethrough. At this point, the space between the base end side outer edge **842** and the leading end side outer edge **841** is sealed with an O-ring, or with an adhesive sealant such as silicon resin or epoxy resin.

As illustrated in FIG. **10**, the connector section **85** is disposed inside the base end side outer edge **842**, and bridges (electrically connects) the multiple plug-side electrical contact points **841**C and the plug-side printed circuit board **86**. The connector section **85** is equipped with a flat insulator **851** including a hole **851**A through which the optical fiber **8**A1 is inserted, and multiple contacts (not illustrated) made of conductive material that penetrate the insulator front-to-back. The multiple contacts electrically connect to each of the multiple plug-side electrical contact points **841**C projecting out from the base end side of the leading end side outer edge **841**, and also electrically connect to the plug-side printed circuit board **86**, either directly or through connectors (not illustrated) and electrical interconnects **88**.

As illustrated in FIG. **10**, the plug-side printed circuit board **86** is disposed in a plane that includes the central axis A×A, and bridges the multiple plug-side electrical contact points **841**C and the multiple electrical cables **8**A2 that constitute the cable section **8**A.

The elastic member **87** is a member that inhibits twisting of the cable section **8**A around the inner edge perimeter of the base end portion of the base end side outer edge **842**. Additionally, the leading end portion of the elastic member **87** fits into the base end portion of the base end side outer edge **842**, with the cable section **8**A internally inserted therethrough. At this point, the space between the elastic member **87** and the base end side outer edge **842** is sealed with an O-ring, or with an adhesive sealant such as silicon resin or epoxy resin.

As illustrated in FIG. **9** or **10**, the receptacle **5**B is equipped with a receptacle-side first outer edge **511**, a receptacle-side cover member **512** (FIG. **10**), a receptacle-side collimator **513**, a receptacle-side second outer edge **514**, and a receptacle-side printed circuit board **515**.

The receptacle-side first outer edge **511** has a tubular shape in which are formed integrally a tubular large hole section **511**A, which is positioned on the leading end side (the side that connects to the plug **8**C), and a tubular small hole section **511**B, which is positioned on the base end side and which has smaller inner hole dimensions that the inner hole dimensions of the large hole section **511**A. Note that the receptacle-side first outer edge **511** is tubular, but is not limited to being cylindrical, and may also be configured as a tube having an elliptical, square, polygonal, or some other cross-sectional shape.

The large hole section **511**A is formed so that the inner hole dimensions are slightly larger than the outer circumferential dimensions of the plug-side first outer edge **81**. Additionally, the large hole section **511**A is formed so that the lengthwise dimension (the dimension in the height direction of the tube) is slightly larger than the projection dimension from the plug-side second outer edge **84** (leading end side outer edge **841**) on the plug-side first outer edge **81**.

The receptacle-side cover member **512** is made of an optically transparent plate, placed against the step portion of the large hole section **511**A and the small hole section **511**B, and joined to the receptacle-side first outer edge **511**. Note that the joining method may adopt the same joining method as the method of joining the plug-side cover member **82** to the plug-side first outer edge **81**, or adopt a different joining method. Also, the receptacle-side cover member **512** may be made of the same material as the plug-side cover member **82**, or may be made of a different material if the material has an optical transmittance by which optical communication may be established.

As illustrated in FIG. **10**, the receptacle-side collimator **513** is inserted through the small hole section **511**B. Additionally, the receptacle-side collimator **513** guides light (an optical signal) emitted from the plug-side collimator **83** to an internal circuit of the control device **5** through an optical fiber **55** (FIG. **10**) that acts as an optical transmission line, for example.

In the case of disposing the receptacle-side collimator **513**, the mechanical connection with the plug **8**C does not have to be as precise compared to a configuration that omits the receptacle-side cover member **512**, thereby making fabrication of the receptacle **5**B easier.

The inner perimeter of the receptacle-side second outer edge **514** has a tubular shape allowing the insertion of the plug-side second outer edge **84**. Additionally, the leading end portion of the receptacle-side first outer edge **511** is inserted into the receptacle-side second outer edge **514** so that the base end portion projects outward.

The receptacle-side printed circuit board **515** is equipped with a board body **515**A and multiple receptacle-side electrical contacts **515**B.

As illustrated in FIG. **10**, the board body **515**A includes a hole **515**C that penetrates front-to-back in an approximate center portion. Additionally, the receptacle-side first outer edge **511** fits into the hole **515**C.

The multiple receptacle-side electrical contacts **515**B are made from a conductive material to electrically connect to the board body **515**A, and also project into the tube of the

receptacle-side second outer edge **514**. The receptacle-side electrical contacts **515**B are arranged at a certain interval in the circumferential direction of the receptacle-side first outer edge **511**.

Additionally, the board body **515**A bridges the multiple receptacle-side electrical contacts **515**B and an internal circuit of the control device **5** through multiple electrical cables **56** (FIG. **10**), for example.

In the state in which the plug **8**C and the receptacle **5**B discussed above are mechanically connected to each other, the plug-side first outer edge **81** is inserted into the receptacle-side first outer edge **511** (large hole section **511**A). Additionally, in this state, the plug-side collimator **83** (the light-emitting end of the optical fiber **8A1**) and the receptacle-side collimator **513** (the light-incident end of the optical fiber **55**) face each other. In other words, this state is one in which an optical signal (imaging signal) output from the camera head **9** through the cable section **8**A (optical fiber **8A1**) is transmittable to an internal circuit of the control device **5** through the plug **8**C and the receptacle **5**B (a state enabling optical communication).

Additionally, in the state in which the plug **8**C and the receptacle **5**B are mechanically connected to each other, the plug-side second outer edge **84** is inserted into the receptacle-side second outer edge **514**, and the multiple plug-side electrical contact points **841**C are electrically connected to the multiple receptacle-side electrical contacts **515**B, respectively. Additionally, in this state, controls signals, supplied power, and the like output from an internal circuit of the control device **5** are transmittable to the transmission cable **8** (camera head **9**) through the receptacle **5**B and the plug **8**C.

FIG. **11** is a diagram illustrating the major configuration of an endoscopic device according to Embodiment 3 of the present disclosure, and is an exploded perspective view illustrating the configuration of the plug **8**C of the endoscopic device **1**A illustrated in FIG. **8**. FIG. **12** is a diagram illustrating the major configuration of an endoscopic device according to Embodiment 3 of the present disclosure, and is a partial cross-section view illustrating the configuration of the plug **8**C of the endoscopic device **1**A illustrated in FIG. **8**. The cross-section view illustrated in FIG. **12** is a partial cross-section view taking a plane approximately parallel to the central axis A×A as the cross-section.

As illustrated in FIGS. **10** to **12**, the plug **8**C additionally includes a protective case **89** which is supported by the plug-side printed circuit board **86**, and which protects the optical fiber **8A1** passing over the board. The optical fiber **8A1** is inserted through the hollow space formed by the faces of the protective case **89** and the plug-side printed circuit board **86** facing each other.

The protective case **89** is formed by press-working SUS, for example. The protective case **89** is screwed onto the plug-side printed circuit board **86**, for example. By pressing and securing the protective case **89** onto the plug-side printed circuit board **86**, the formation of a gap between the protective case **89** and the plug-side printed circuit board **86** is inhibited, thereby enabling the optical fiber **8A1** to be disposed without being caught in a gap formed between the protective case **89** and the plug-side printed circuit board **86**. Note that the protective case **89** may be formed using a resin, such as polyphenylene sulfide (PPS), for example, may be formed by cutting metal, or may be formed with a composite material of resin and metal.

Additionally, as illustrated in FIG. **12**, the optical fiber **8A1** is curved so as to draw a circle while being guided by the inner wall of the protective case **89**, with any extra length of the optical fiber **8A1** wrapping around. This wraparound portion absorbs force in the extension direction of the optical fiber **8A1** when the transmission cable **8** is bent or twisted. Herein, the inner wall of the protective case **89** according to Embodiment 3 includes planar sections **891** to **894** extending in tangent directions to the direction by which the optical fiber **8A1** is wrapped around. Consequently, the optical fiber **8A1** may be wrapped around more stably.

According to Embodiment 3 discussed above, the protective case **89** that protects the optical fiber **8A1** passing over the plug-side printed circuit board **86** is including, thereby providing a configuration related to the protection of the optical fiber **8A1**. In addition, the formation of a gap between the protective case **89** and the plug-side printed circuit board **86** is inhibited, the protective case **89** is easily fabricated, and the protective case **89** may be attached easily and reliably.

In addition, according to Embodiment 3, parts of the inner walls of the protective case **89** form planar sections **891** to **894** extending in tangent directions to the wraparound direction of the optical fiber **8A1**. Consequently, when wrapping around extra length of the optical fiber **8A1** on the protective case **89**, the optical fiber **8A1** may be wrapped around more smoothly and the shape of the wrap may be maintained better compared to a configuration in which the wall faces form corners.

The foregoing thus describes embodiment for carrying out the present disclosure, but the present disclosure should not be limited only to the embodiments discussed in the foregoing. In the foregoing embodiments, the control device **5** is described as conducting signal processing and the like, but such signal processing may also be conducted on the camera head **9** side.

Herein, in the foregoing Embodiments 1 and 2 as well as Modifications 1 to 3, the size of the image sensor section **100** used in the camera head **9** is from 8×6 (mm) to 50×40 (mm), for example, but the size of the image sensor section **100** provided in the leading end section **204** of the endoscopic device **1***a* is from 2×2 (mm) to 6×6 (mm), for example. The image sensor section **100** used in the camera head **9** is large compared to the size of the image sensor section in the endoscopic device **1***a* which is a flexible scope, and the deformation due to thermal expansion is large. For this reason, the configuration of the imaging section **92** according to the foregoing Embodiment 1 is considered to be particularly effective for the image sensor section **100** used in the camera head **9**.

As above, a medical imaging device and endoscopic device according to an embodiment of the present disclosure is useful for making a reliable electrical connection between an image sensor and a substrate, even when exposed to high temperature.

It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

What is claimed is:

1. An endoscopic device, comprising:

imaging circuitry configured to sense and convert light into one or more electrical signals;

a substrate that is electrically connected to the imaging circuitry; and

an intermediate layer, interposed between the imaging circuitry and the substrate, that provides at least a portion of an electrical conduction path between the imaging circuitry and the substrate;

a plurality of connectors provided between the intermediate layer and the substrate, and the plurality of connectors configured to electrically connect the intermediate layer and the substrate; and

underfill provided between the intermediate layer and the substrate, the underfill formed of a material with less elasticity than the substrate.

2. The endoscopic device according to claim **1**, wherein the underfill is provided between the intermediate layer and the substrate to surround the plurality of connectors.

3. The endoscopic device according to claim **2**, further comprising:

a holder configured to hold the imaging circuitry;

wherein the holder provides another portion of the electrical conduction path between the imaging circuitry and the intermediate layer.

4. The endoscopic device according to claim **3**, wherein the holder is a part of a housing, and

the imaging circuitry is provided inside the housing.

5. The endoscopic device according to claim **3**, wherein the holder comprises a material having a coefficient of thermal expansion smaller than a coefficient of thermal expansion of the substrate.

6. The endoscopic device according to claim **3**, wherein the underfill comprises a material having a coefficient of thermal expansion between a coefficient of thermal expansion of the intermediate layer and a coefficient of thermal expansion of the substrate.

7. The endoscopic device according to claim **3**, wherein material of the intermediate layer comprises a material having the same or substantially the same coefficient of thermal expansion as at least one of the holder or the substrate.

8. The endoscopic device according to claim **3**, wherein the intermediate layer comprises a material having a first coefficient of thermal expansion whose value is 95% or greater than a second coefficient of thermal expansion of the holder, and less than or equal to an intermediate value between the second coefficient of thermal expansion of the holder and a third coefficient of thermal expansion of the substrate.

9. The endoscopic device according to claim **1**, further comprising:

a holder configured to hold the imaging circuitry, wherein the imaging circuitry is electrically

connected to the substrate via the holder and the intermediate layer.

10. The endoscopic device according to claim **9**, wherein the holder comprises a material having a coefficient of thermal expansion smaller than a coefficient of thermal expansion of the substrate.

11. The endoscopic device according to claim **9**, wherein material of the intermediate layer comprises a material having a same or substantially the same coefficient of thermal expansion as at least one of the holder or the substrate.

12. The endoscopic device according to claim **9**, wherein the intermediate layer comprises a material having a first coefficient of thermal expansion whose value is 95% or greater than a second coefficient of thermal expansion of the holder, and less than or equal to an intermediate value between the second coefficient of thermal expansion of the holder and a third coefficient of thermal expansion of the substrate.

13. The endoscopic device according to claim **9**, wherein the holder is a part of a housing, and

the imaging circuitry is provided inside the housing.

14. The endoscopic device according to claim **9**, further comprising:

solder balls that electrically connect the imaging circuitry and the intermediate layer;

wherein the imaging circuitry is electrically connected to the substrate via the holder, the solder balls, and the intermediate layer.

15. The endoscopic device according to claim **1**, wherein the underfill comprises a material having a coefficient of thermal expansion with a value between a coefficient of thermal expansion of the intermediate layer and a coefficient of thermal expansion of the substrate.

16. The endoscopic device according to claim **15**, further comprising:

a holder configured to hold the imaging circuitry;

wherein the imaging circuitry is electrically connected to the substrate via the holder and the intermediate layer.

17. The endoscopic device according to claim **16**, wherein the holder comprises a material having a coefficient of thermal expansion smaller than that of the substrate.

18. The endoscopic device according to claim **16**, wherein material of the intermediate layer comprises a material having a same or substantially same coefficient of thermal expansion as at least one of a coefficient of thermal expansion of the holder or the substrate.

19. The endoscopic device according to claim **16**, wherein the intermediate layer comprises a material having a first coefficient of thermal expansion whose value is 95% or greater than a second coefficient of thermal expansion of the holder, and less than or equal to an intermediate value between the second coefficient of thermal expansion of the holder and a third coefficient of thermal expansion of the substrate.

20. The endoscopic device according to claim **16**, further comprising:

solder balls that electrically connect the imaging circuitry and the intermediate layer;

wherein the imaging circuitry is electrically connected to the substrate via the holder, the solder balls, and the intermediate layer.

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